METHOD FOR GENERATING DATA THAT CAN BE USED TO ASSESS THE COGNITIVE OR SENSORIMOTOR CAPABILITIES OR CAPACITIES OF TEST PERSONS

The invention is situated in the field of diagnostics in the widest sense and concerns a method according to the first independent patent claim. The method provides a way to generate data that can be used to assess the cognitive or sensorimotor capabilities or capacities of test persons.

In modern times, in which efficiency, i.e., the highest possible utilization of all resources, thus also of human mental resources, is very important, particularly in professional life, the demands on the planning and mid-career new or reorientation of one's own career and of the careers of others have risen enormously. For the planning of a promising career it is also important to be able to adequately assess the cognitive or sensorimotor capabilities of the affected person. People want to work in areas in which they have the capability for the greatest possible achievements, they want to choose employees who can contribute high levels of ability to their intended occupation, and they want as much as possible to avoid career terminations due to insufficient capabilities.

This wish is satisfied, in accord with available technology, with a large selection of psychological tests a person takes whose results are then interpreted by expert personnel. In most cases the test consists in that a test person solves a problem by mental effort and in that then the solution of the task is assessed. In many cases, however, it is not, or only inadequately, or only to a limited extent, possible to figure

out from this solution how the test person arrived at the solution, thus what capabilities he or she employed for this. This "how," which is much less tied to the nature of the test than is its result, would be particularly interesting and revealing for assessing capabilities.

Various methods with which brain activities can be observed are known from brain research. Using such methods it becomes possible not only to temporally trace the brain activities (e.g. neural discharges) that, e.g., accompany sensory or also cognitive activities, but also to localize them in the brain. To this end, e.g., brain field potentials are measured using the methods of magnetoencephalography or electroencephalography, from which local sources of potentials (sources) are mathematically computed. Using magnetoencephalography, electrical potentials essentially induced by field potentials are registered in a large number of induction coils arranged around the head of a test person. On the basis of the electrical potentials simultaneously registered in various induction coils, the origin of the field potential (location where the potential arises) is localized in the brain, making it possible to assign different brain functions to different parts of the brain.

Observations of brain activities similar to those using magnetoencephalography or electroencephalography are also possible, e.g., with the aid of positron emission tomography (PET), with which essentially local and temporal changes in cerebral blood flow can be observed, or with the aid of functional magnetic resonance imaging (fMRI).

The invention has the task to show a method with which data can be generated that can be used to assess the cognitive or sensorimotor capabilities or capacities of test persons, that is, for example, to classify test persons in appropriate skill categories, to directly compare test persons with regard to a specific capability, or to assess a specific performance of a test person (e.g., to assess whether a statement is or is not a lie; lie detector).

This task is solved using the method as defined in the patent claims.

The method according to the invention starts from a set of measuring data which is collected from a test person using an available measuring procedure (e.g., magnetoencephalography, electroencephalography, PET, fMRI), and as a sequence of a large number of measuring samples represents a test person's brain activities. When using magnetoencephalography, each measuring sample consists of the potentials registered by the induction coils at the corresponding moment in time (sampling point). The set of measuring data is registered in time frames synchronized with the placing of the test person in various test situations. Ideally each such time frame begins essentially simultaneously with a new test situation and is of a predetermined length adapted to the type of test situation. The test situations contain visual, acoustic, or somatosensory stimuli addressing the experiences of the test persons in the area of the capabilities or capacities to be assessed.

On the basis of the measuring samples registered in the time frames, relevant changes in brain activity are traced and localized. In other words, essentially brain regions are registered in which brain activity changes in such a relevant way that the test situation in which the test person was placed can be assumed to be the cause of the change. From measuring samples generated using magnetoencephalography or electroencephalography, the potential sources (locations where the potential arose) are calculated in order to trace and localize the relevant activity changes. The measuring samples and/or the data calculated from them that describe the sources are filtered in order that only relevant sources are registered.

The relevant changes in brain activity localized from the registered measuring samples are then subdivided into a variety of different groups assigned to predetermined brain regions. This is done generally or per individual time frame or respectively per individual test situation or per group of thematically related test situations. Each group comprises those relevant changes that according to the localization occurred

in the specific region of the brain. The groups of relevant activity changes assigned to the predetermined brain regions are then related to one another.

It has been found that such relationships, which are generated from sets of measuring data gathered on the basis of a variety of different test situations of a predetermined type, can be directly employed for the comparison of different test persons in regard to cognitive or sensorimotor capabilities, whereby the capability to be evaluated determines in particular the type of test situation, the synchronization and length of the time frame for the registration of measuring samples, as well as the definition of the various brain regions. It has further been found that with the aid of such relationships, if established per time frame, or respectively per test situation, or per group of thematically related test situations, very specific cognitive or sensorimotor capacities of test persons can be assessed. It is possible, e.g., to compare such relationship data with the test person's comments on the test situation and thereby to draw conclusions about the truth content of the statements, in the sense of a lie detector.

In order to assess capabilities, the data representing the relationship (relationship data) are, e.g., compared with experimentally determined calibration curves or threshold values, whereby the test person is classified in predetermined ability categories, or the relationship data of various test persons are directly compared with each other.

The method according to the invention thus consists of essentially four steps:

(1) registering measuring samples which represent brain activities in time frames which are synchronized with the placing of a test person in a series of different test situations;

(2) tracing and localizing relevant changes in brain activities from the registered measuring samples (across all time frames or per time frame or per group of time frames);

(3) forming a variety of groups of relevant changes in brain activity, whereby each group is assigned to a predetermined brain region, i.e., contains changes that were localized in this brain region;

(4) creating a predetermined relationship between the groups assigned to the various brain regions and preparing the relationship data for assessment.

The present invention is based on the discovery made using magnetoencephalography of a correlation between the ELO ranking list of chess players and a relationship between the number of potential sources in the frontal, occipital and parietal lobes (memory) and the number of potential sources in the temporal lobe, hippocampus and limbic system (encoding) registered while playing chess. [Amidzic, O. et al., *Nature*, vol. 412, 9 August, 2001].

An example of the method according to the invention, to be described in more detail below, is used to assess the ability of test persons to use experience in a predetermined area to solve problems in this area (assessment of expertise). Extensive use of experience indicates a high level of capability for the most varied areas of activity, in particular in the strategic area.

A test person is placed in a series of different test situations. The test situations are various problems, e.g., problems presented to the test person in visualized form which are solvable using the expertise to be evaluated. Measuring samples representing the brain activity of the test person are registered during time frames that begin with each presentation, or immediately following them, and last from 0.1 to 3000 seconds. For example, using an available method (magnetoencephalography)

the brain field potentials of the test person are measured with a sampling frequency of 10 to 5000 Hz (preferably 20 to 1400 Hz).

From the registered measuring samples, relevant activity changes are traced and localized in that observed activity changes are subjected to an admissibility test appropriate for the applied model (filtering) and relevant changes are isolated, and in that the location where they appear in the brain is determined. Potential sources are thus calculated from the field potentials registered using magnetoencephalography. Sources in a frequency band of 4 to 80 Hz (preferably 20 to 40 Hz, cognitive brain activity) with a “goodness of fit” greater than 90% are isolated and used further for the assessment. If applicable, the intensities of the sources can also be used for a filtration.

The relevant changes traced and localized with the reliability test (e.g. sources determined by magnetoencephalography) are then assigned to different groups based on the brain region (locality) of their occurrence. For an assessment of expertise, a first brain region comprises the frontal, occipital and parietal lobes (memory), and a second brain region comprises the temporal lobe, the hippocampus and the limbic system (encoding).

The groups of relevant changes in brain activity assigned to different brain regions are then related to one another. For example, the relative numbers of relevant changes observed in the predetermined brain regions are determined, e.g., in the two brain regions named above, to which on the one hand the memory function, and on the other hand the encoding function are attributed. A large share of relevant activity changes in the brain region of the frontal, occipital and parietal lobes points to a high level of expertise (extensive use of the relevant experience). A large share of relevant activity changes in the brain region of the temporal lobe, hippocampus and limbic system indicates a low level of expertise.

The data describing the aforementioned relationship (relationship data) are prepared for assessment, e.g., they are, together with comparison data, calibration curves and/or threshold values, visualized, or they are directly processed into a verbal assessment.

The realization of the method according to the invention described above can, slightly modified, also be used to test whether or not a test person associates certain test situations with personal experiences, thus, e.g., whether or not they have already seen the pictures presented to them. The method can also be used, e.g., as a lie detector, if the relationship data are compared to statements of the test person. Thereby essentially the same thing is done as described above for the assessment of a capability, except that the analysis of the measuring samples is not carried out generally, i.e., using all time frames or respectively test situations, but rather per individual time frame, or per individual test situation, or per group of thematically related test situations. Thus the test person is presented, e.g., a series of portraits or pictures of situations. In each time frame following a presentation, measuring samples are registered and relevant activity changes are traced and localized from them. A large proportion of such relevant changes that can be assigned to the brain region of the frontal, occipital and parietal lobes, or respectively a small proportion of relevant activity changes that can be assigned to the brain region of the temporal lobe, hippocampus and limbic system, indicates that the test situation addresses experiences, i.e., that the person shown in a portrait or a picture of a situation is known to the test person.

Further forms of realizing the method according to the invention show differences from the above described, exemplary form of realization, e.g., differences in the synchronization of the measuring sample registration with the placement in the test situation, differences in the reliability tests for selecting the relevant activity changes, differences in the mutually demarcated brain regions, and/or differences in the calculation of the relationship data. For example, it is conceivable to delay and/or extend the time frames for registering measuring samples from the moment when the test

person is placed in the test situation in order to assess his/her way of solving the presented problem rather than to assess the first reaction to material useful for the solution. It is possible to specify more than two, but smaller, brain regions, and it is possible to use for the calculation of the relationship not the number of relevant activity changes in the various brain regions, but instead, for example, the summed-up intensities of the activity changes, or similar quantities.

The optimal parameters of the method according to the invention, to which the selection of test situations and their temporal sequence also belong, are to be established by experiment for each application, and the comparison areas and/or threshold values for classifying or comparing test persons are likewise to be determined experimentally.

A device for carrying out the method is essentially a data processing system. This data processing system comprises an interface for the input of a large number of measuring samples which are provided by a device for measuring activities in the brain of a test person. The device further comprises the following means: a means with which the test person can be placed in a series of different test situation, a means for synchronizing test situations and measuring sample registration, a means for tracing and localizing relevant activity changes from the registered measuring samples, a means for forming a variety of groups of relevant activity changes by assigning the locations of changes to various predetermined brain regions, a means for determining a relationship among the groups of relevant activity changes, and a means for preparing the relationship data for assessment.

The aforementioned data processing system comprises, e.g., a suitably programmed computer and a monitor or loudspeaker with which test situations are visually or acoustically presented to the test person. A storage medium is also to be protected on which a program is stored which will enable a normally equipped computer to perform the procedure according to the invention.